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Wyndal M. Goodman
University of Arkansas, Fayetteville

Albert E. Ogden
Southwest Texas State University, aogden@mtsu.edu

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A PRELIMINARY INVESTIGATION OF GROUND-WATER OCCURRENCE IN THE ATOKA FORMATION OF POPE AND FAULKNER COUNTIES, ARKANSAS

WYNDAL M. GOODMAN
Department of Geology
University of Arkansas
Fayetteville, Arkansas 72701

ALBERT E. OGDEN
Edwards Aquifer Research and Data Center
Southwest Texas State University
San Marcos, Texas 78666

ABSTRACT

One hundred and twelve wells having drillers' logs were studied in Pope and Faulkner counties. Sixty-six of the wells produced water from shales and siltstones of the Atoka Formation while 46 produced from interbedded Atoka sandstones. Drillers' estimated well yields ranged from 1 to 100 gpm, but the median yield was only 9 gpm. Well depths ranged from 30 to 337 feet with a median depth of 100 feet. Ground-water is usually obtained from a series of low-producing confined aquifers of low artesian pressure. Pressure head and production were shown, statistically ($\alpha = .01$), to decrease with increasing well depth. This indicates that fractures and bedding-plane partings become more tight with depth associated with the increasing lithostatic pressure. Ground-water flow directions are generally to the south towards the Arkansas River with static water levels strongly conforming to the topography ($\alpha = 0.001$).

A resistivity study was performed near Guy in Faulkner County to investigate the hypothesis that production is largely controlled by fracture porosity. The tri-potential resistivity technique was utilized to verify the presence of suspected fractures delineated from aerial photographs. Existing wells in the area produce estimated yields of 1 to 20 gpm. The well located in this study on verified fractures produced 120 gpm.

INTRODUCTION

Rural residents and small communities in Pope and Faulkner counties, Arkansas, (Figure 1) utilize ground water to meet their water needs. In these counties, ground water occurs in the alluvium of the Arkansas River and within porous zones of the Pennsylvanian aged Atoka Formation. This study is concerned only with the Atoka Formation aquifers which underlie a vast majority of the counties.

Previous hydrogeologic studies are limited and somewhat lacking in definitive results which would aid in ground-water prospecting. There are two reports which deal directly with ground water in the study area. These are by Cordova (1963) and Bedinger et al. (1963) and were performed in conjunction with the Arkansas River navigation project of the 1960's. These reports are of a general nature in which only a couple hundred wells were investigated throughout the entire Arkansas Valley. Many of these wells were in the alluvium. Tolman (1979) analyzed surface linear trends using remote sensing data and joint orientations taken in the field for comparisons to natural gas production. Tolman's findings may someday prove useful in evaluating ground-water occurrence, movement, and prospecting techniques.

To date, the site selection of water wells has been by random choice without regard to geologic control on well yield. As a result, many dry holes and wells of low yield have been drilled. This study attempts to determine a framework of geologic control over water yield to wells and investigates the feasibility of surface resistivity surveys in locating zones of concentrated fractures which may produce higher yields.

Physiography and Geology

Pope and Faulkner counties are centrally located in the Interior Highlands region of Arkansas and lie mostly within the Arkansas Valley physiographic province. Pennsylvanian aged Atoka sandstones, siltstones, and shales dominate the outcrop area of both counties and are the dominant hydrostratigraphic unit dealt with in this report. The

Atoka is over 10,000 feet thick and is faulted and folded. East-west trending faults are common with a general structural transition from north to south of predominately normal to reverse faulting, respectively. The rock strata generally dip to the south as does surface elevation. Plotting of the static water levels show that the piezometric surface(s) slopes in a southern direction, as well, towards the Arkansas River.

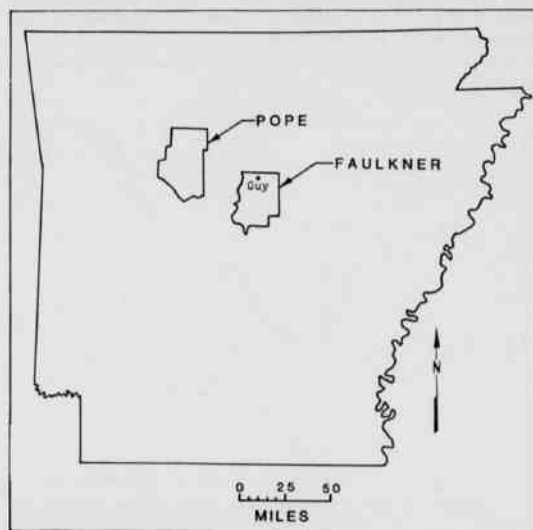


Figure 1. Location of study areas (Pope and Faulkner Counties).

METHODS

Records of water wells for Pope and Faulkner counties were obtained from the Arkansas Geologic Commission. From these reports, 71 wells in Pope County and 41 wells in Faulkner County were accurately located on topographic maps with the aid of county plat books. Geologic maps provided outcrop and structural information relative to a respective well. Data obtained from the well records and topographic maps were: (1) depth of well, (2) depth of water, (3) static water level, (4) drillers' estimates of yield, (5) depth to bedrock, (6) well surface elevation, (7) static water level below land surface, and (8) the general lithology of the producing horizon(s). Inter-relationships among the data were then tested using the Spearman-rank correlation coefficient test (Siegel, 1956).

As a means of testing to what degree well production is controlled by fracturing, an earth resistivity study was performed three-fourths of a mile north of Guy in Faulkner County. A Soiltest Strata Scout R-40C resistivity unit was employed in siting of the well. The tri-potential technique of the standard Wenner array (Eddy, 1980) was utilized to locate fractures by making lateral traverses. These fractures were initially delineated (as photo-lineaments) using 1:20,000 black and white aerial photographs. Resistivity depth profiling was also performed and compared to the drillers' lithologic logs as each well was drilled.

RESULTS

The Atoka Formation was found to contain several water bearing horizons. A total of 112 wells were accurately located. Sixty-six wells produced from siltstones and shales, while 46 produced from sandstones. The hydrologic interaction between the sands and the siltstones and shales can only be speculated upon, but in many wells, several horizons of low yield had to be penetrated to produce sufficient quantities of water. Confined conditions of low artesian pressure prevail throughout the area.

Depths of the wells range from 30-337 feet with a mean and median of 100 and 113 feet, respectively. Drillers' estimated yields range from 1-100 gpm with a median and mean of 8 and 9 gpm, respectively. The movement of ground water is largely a function of grain size, the amount of cementation and compaction, the number and size of bedding-plane partings, and the amount of fracturing. All of these factors are highly variable in the Atoka Formation which explains the large range in yield. Depth to producing horizon ranges from 11-180 feet with a mean and median of 55 and 65 feet, respectively. Generally, deeper wells do not produce as much as shallower wells.

In response to an inquiry by a Faulkner County landowner to locate an irrigation well on his property, the tri-potential resistivity technique was employed in an attempt to locate a fracture zone. A review of well records in the surrounding area, revealed yields generally less than 5 gpm. Several lateral traverses located an anomalous resistive low zone. A vertical sounding profiling was subsequently performed over this low zone. The graphs of these data are shown in Figures 2 and 3. The landowner was instructed to drill at this site and upon drilling encountered production of 120 gpm within the first 70 feet of depth. A subsequent pumping (aquifer) test performed for a duration of 48 hours at 120 gpm produced a drawdown of only 11 feet. Complete recovery occurred in 45 minutes. Later, a second well was drilled, but produced only 15 gpm. This well was located in the vicinity of the 120 gpm well, but was not sited by resistivity. An older well on the same property that was randomly located produces less than 10 gpm.

Statistical relationships

The statistical relationships for all parameters recorded from the well logs and topographic maps were tested using the Spearman rank correlation coefficient test with the aid of computer SAS (Barr et al., 1976) procedures. A positive relationship at an alpha significance level of 0.0001 was found between static water levels and well surface elevations as is expected (Table). Pressure head (static water level) as well as production, were shown statistically ($\alpha = -0.1$) to decrease with increasing depth. This indicates that fractures and bedding-plane partings become tighter with increasing depth due to increasing lithostatic pressure.

SUMMARY

The statistical relationships noted may only affirm what may be intuitively obvious. However, these statistically confirmed relationships may act as a base for more in depth study of the hydrogeologic nature of the area. Perhaps the most significant aspect of this study is the proven application of surface resistivity in identifying zones favorable for high production from relatively shallow wells. The area's ground-water resources are plentiful but undeveloped, and still much remains to be determined about them. Future studies should include a photo-lineament analysis, piezometric surface mapping, aquifer tests, and the determination of the control of fault and fold axes on ground-water movement so that one day the area's valuable ground-water resources can be properly developed and protected.

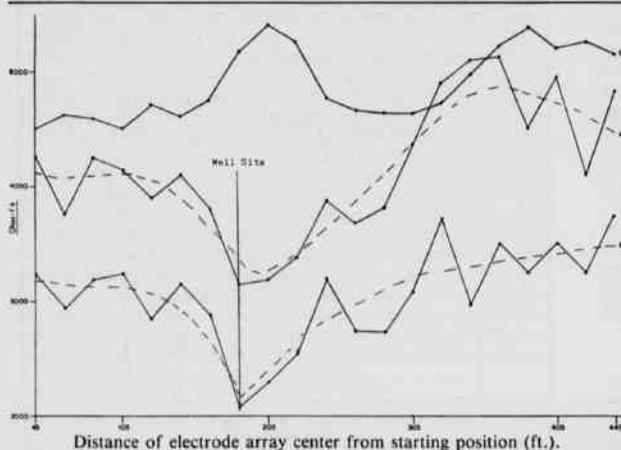


Figure 2. Plot of lateral resistivity traverse using tri-potential technique.

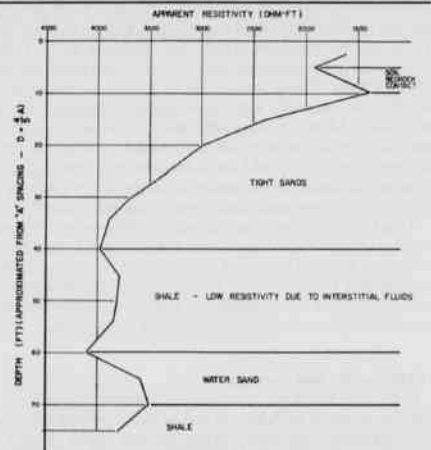


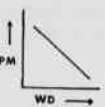


Figure 3. Plot of resistivity vertical sounding profile.

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Table. Significant statistical relationships.

PARAMETER	ALPHA SIGNIFICANCE LEVEL	RELATIVE PLOT
STATIC LEVEL VS. WELL SURFACE ELEVATION	= 0.0001	
PRESSURE HEAD VS. WELL DEPTH	= -0.1	
YIELD VS. WELL DEPTH	= -0.1	

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